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INDIANA DEPARTMENT OF ENVIRONMENTAL MANAGEMENT
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Water

Lake Nutrients Criteria
NPDES Permit Limit Development

External Workgroup Meeting

May 22, 2012

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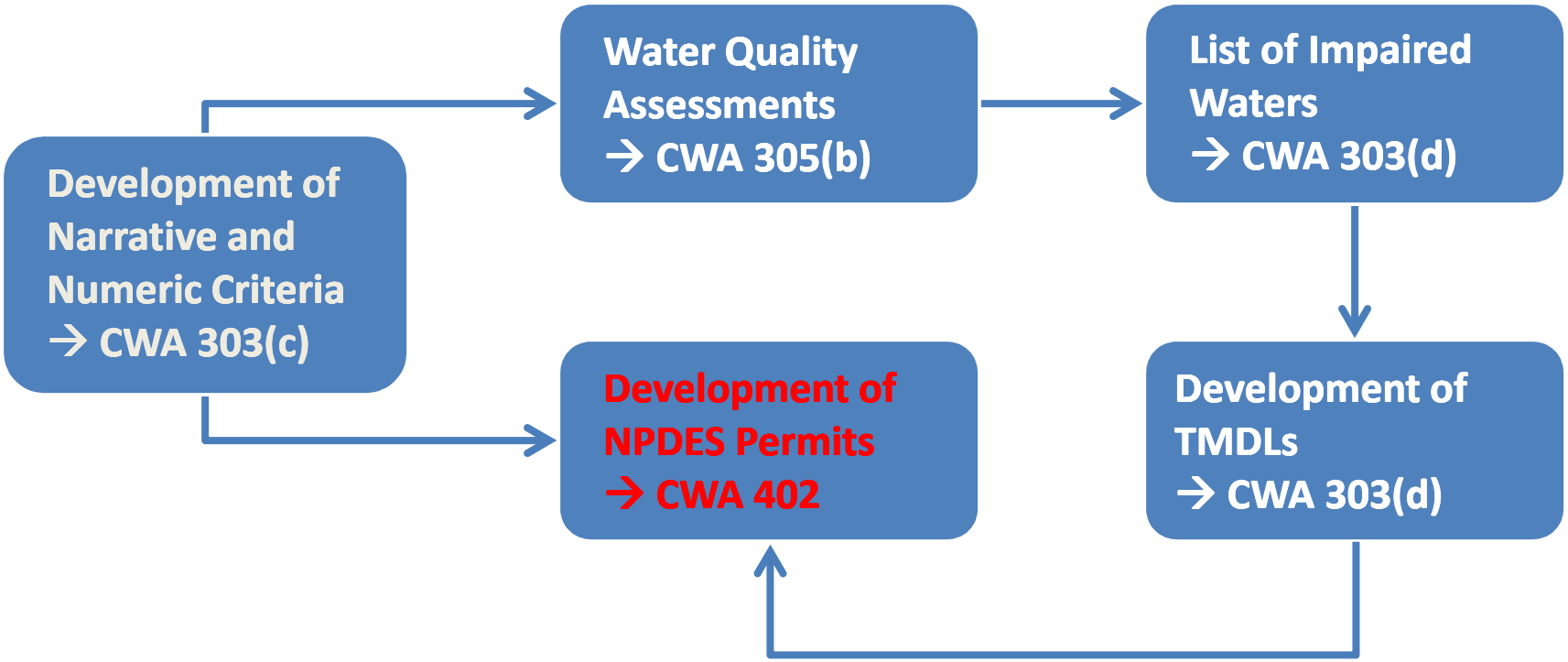
NPDES Permits Branch

IDEM Office of Water Quality

Roadmap for Implementation of Nutrient Criteria for Lakes



Outline of Implementation Discussion

- Regulatory Flexibility
- Criteria Features Critical to Implementation
- Calculating Wasteload Allocations
- Other States' Lake Nutrient Criteria Implementation Provisions
- Lakes and Reservoirs with Point Source Contributors
- Implementation Examples

Regulatory Flexibility: Water Quality Standards

General Federal Requirements (40 CFR Part 131)

- Designated Uses
- Water Quality Criteria
  - Numeric and/or Narrative Criteria
    - EPA recommended numeric criteria (CWA Section 304(a))
    - Allow site-specific modifications of EPA numeric criteria
    - Numeric criteria based on other scientifically defensible methods
- Antidegradation Standard and Implementation Procedures

State Discretionary

- General Policies (e.g., Mixing Zones, Critical Low-Flows, Variances)

Regulatory Flexibility: Water Quality-Based Effluent Limitations

General Federal Requirements (40 CFR 122.44(d)(1))

- **Reasonable Potential Analysis:** A WQBEL is required for a pollutant that is or may be discharged at a level that will cause, have the reasonable potential to cause or contribute to an excursion above a narrative or numeric water quality criterion.
- The reasonable potential analysis must account for existing controls on point and nonpoint sources of pollution, the variability of the pollutant or pollutant parameter in the effluent, and where appropriate, the dilution of the effluent in the receiving water.
- The level of water quality to be achieved by a WQBEL is derived from and complies with WQS.
- A WQBEL must be consistent with the assumptions and requirements of any available wasteload allocation in an EPA approved TMDL.

Regulatory Flexibility
Water Quality-Based Effluent Limitations

Specific Great Lakes System Requirements
(40 CFR Part 132)

- Water quality criteria, site-specific criteria, variances, TMDLs and wasteload allocations, reasonable potential, loading limits and compliance schedules
- Great Lakes states are not required to apply these requirements to BOD5, dissolved oxygen and phosphorus.

Criteria Features Critical to Implementation
Current Draft Criteria

Criteria developed to protect the following types of waterbodies:

- Natural Lakes
- Reservoirs

Criteria establish concentrations of total phosphorus (TP) and chlorophyll *a* (chl *a*) that protect following designated uses:

- Well balanced warm water aquatic community
- Full body contact recreation
- Public water supply

Criteria Features Critical to Implementation
Current Draft Criteria

Magnitude (parameters considered independently)

- Chl *a*
  - 8 µg/L Natural Lakes and Reservoirs
- TP
  - 25 µg/L Natural Lakes
  - 35 µg/L Reservoirs

Duration

- Growing Season Mean (June thru September)

Frequency of Exceedance

- Once in three years

Criteria Features Critical to Implementation of Current Draft Criteria

General Policies

- **Mixing Zone:** Continue current policy of not allowing mixing zones in lakes and applying the criteria to the undiluted discharge.
- **Critical Low-Flows:** Not applicable
- **Variance:**
  - Individual: allow
  - Streamlined: evaluate need based on ability to meet proposed WQBELs

Criteria Features Critical to Implementation of Current Draft Criteria (continued)

General Policies

- **Site-Specific Criteria:**
  - Modified TP criterion up to a maximum of 98 µg/L for natural lakes and 126 µg/L for reservoirs based on site-specific data.
  - The calculation procedure would be included in rule so that EPA approval would not be required when a modified criterion is approved by IDEM.

- **Point of Application of the Criteria (?)**

Criteria Features Critical to Implementation
The Pollutant of Concern

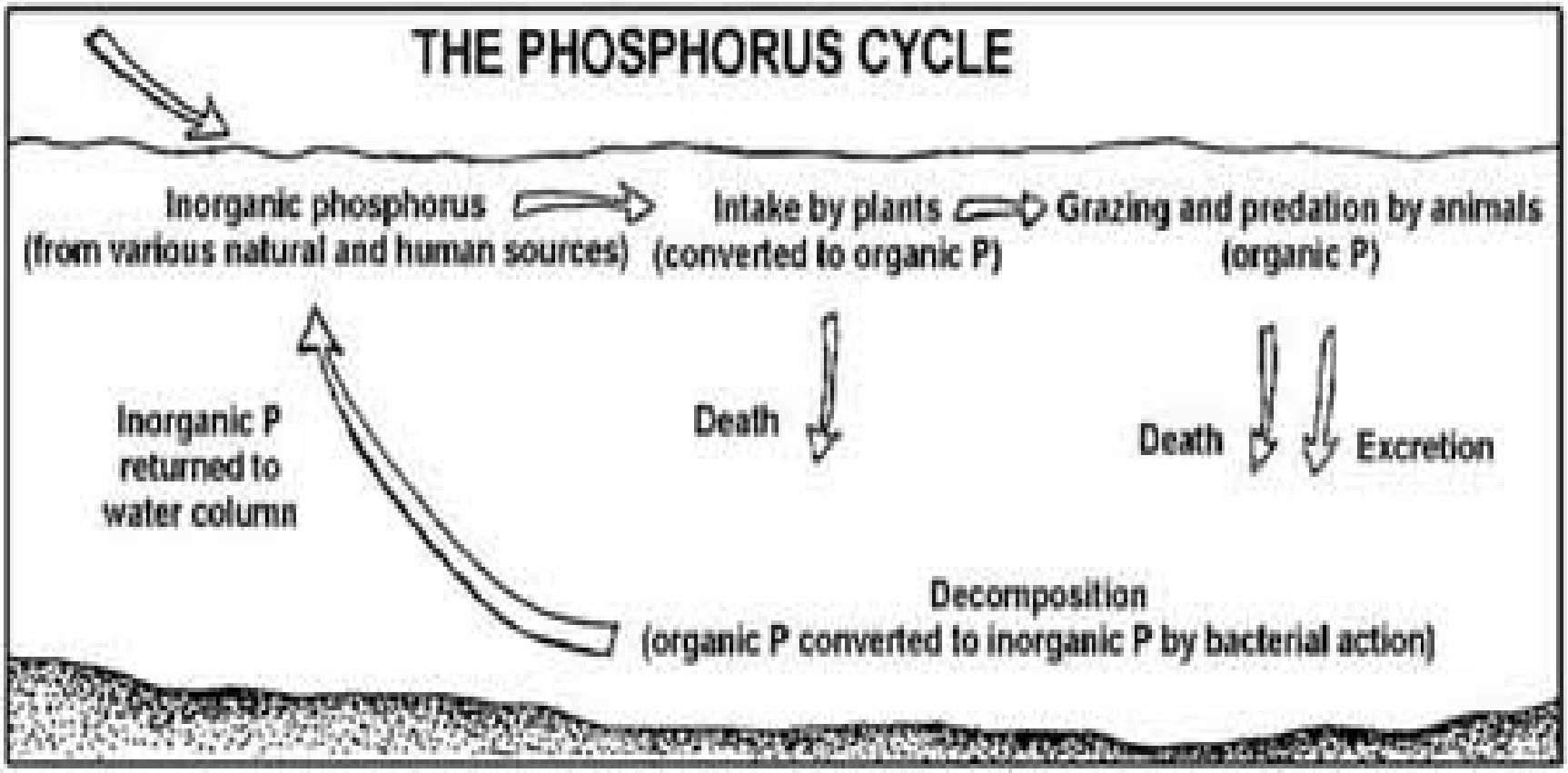
Important Phosphorus Facts for Predicting Water Quality

- Phosphorus exists in surface waters mostly as phosphates in two forms:
  - Organic
    - Bound to plant or animal tissue
  - Inorganic
    - Orthophosphate (PO_4^{-3}), polyphosphates
- Both forms can be dissolved in the water column or adsorbed to particles (suspended).
- Dissolved orthophosphate is the form readily taken in by living organisms.
- Soluble Reactive Phosphorus (SRP): analytical method that measures dissolved orthophosphate plus a small amount of other dissolved forms.
- **TP** is a measure of all forms of phosphorus.

Criteria Features Critical to Implementation
The Pollutant of Concern

Important Phosphorus Facts for Predicting Water Quality (continued)

- Phosphorus changes form as it cycles through lakes and reservoirs:
  - Inorganic phosphorus is taken in by plants & converted to organic P.
  - Organic phosphorus is taken in by animals.
  - Organic phosphorus is decomposed to inorganic phosphorus in sediments.
- Inorganic phosphorus adsorbed to particles in the water column or sediment can be released to the water column if dissolved concentrations are lowered.
- Precipitated forms of inorganic phosphorus (bound to iron and manganese) are found in sediments and can be released when oxygen is not present (anoxia).
- A mass balance can be done on total phosphorus.



From http://upload.wikimedia.org/wikipedia/en/e/eb/Phoscycle-EPA.jpg

Calculating Wasteload Allocations To Meet Water Quality Criteria for Conservative Pollutants

- **Example pollutants:** metals, chloride and ammonia-N
- Mass balance calculation to meet water quality criterion outside the mixing zone during critical conditions considering the following:
  - **Effluent flow:** monthly average
  - **Stream design flow:** based on averaging period of criterion
  - **Mixing zone:** criterion dependent
  - **Background concentration:** geometric mean of representative data

Calculating Wasteload Allocations To Meet Water Quality Criterion for Dissolved Oxygen

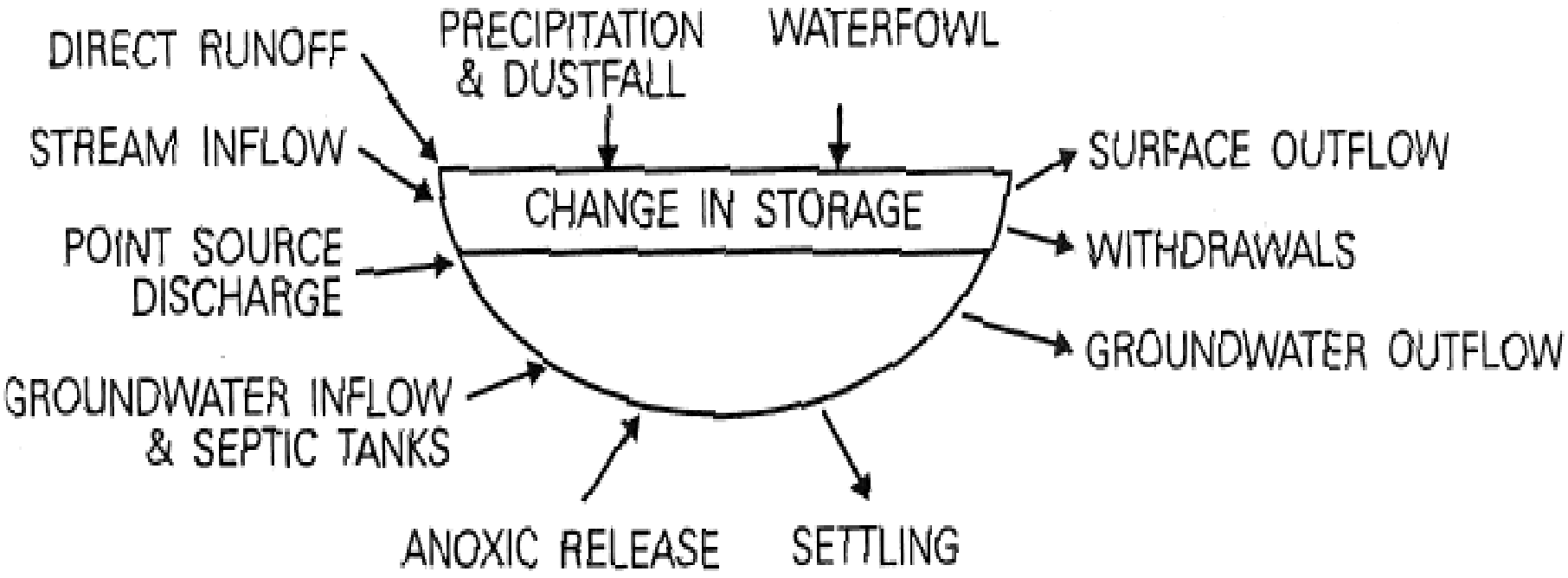
- Water quality simulation to meet dissolved oxygen criterion outside the mixing zone during critical conditions considering effluent concentrations of CBOD5, ammonia-N, dissolved oxygen and the following:
  - **Effluent flow:** monthly average
  - **Stream design flow:** Q7,10 low-flow
  - **Mixing zone:** 100% of stream design flow
  - **Reaction rates:** reaeration, CBOD decay, ammonia-N decay and sediment oxygen demand

Calculating Wasteload Allocations To Meet TP Criterion in Lakes and Reservoirs

U.S. Army Corps of Engineers BATHTUB Model

- Developed and calibrated for reservoirs, but can be used for lakes.
- Performs steady-state water and total phosphorus mass balance calculations considering:
  - **Inputs from:** tributaries, point source discharges, groundwater, direct runoff, internal loading and the atmosphere.
  - **Outputs to:** sediment, groundwater, atmosphere, withdrawal and the lake outlet.
  - Change in storage.
- The calculation is done on a seasonal or annual average and over the entire volume.

Schematic of Phosphorus Budget



Managing Lakes and Reservoirs, North American Lake Management Society, 3rd Edition, 2001.

Calculating Wasteload Allocations to Meet TP Criterion in Lakes and Reservoirs

BATHTUB Model Overview (continued):

- Applies empirical models to account for phosphorus sedimentation and to predict the concentrations of TP and chl *a* in the epilimnion.
- Can be used to link dissimilar segments of a lake or reservoir or multiple lakes and reservoirs and predict TP and chl *a* in each segment.
- Input requirements to calculate TP concentration include flow weighted average inflow concentration, inflow volume, lake surface area, average depth and change in storage.
- Includes calibration factors to match predictions to lake data.

Calculating Wasteload Allocations to Meet TP Criterion in Lakes and Reservoirs

BATHTUB Model Overview (continued):

- Can account for internal loading directly, but encouraged to first adjust calibration of sedimentation equations which implicitly account for internal loading.
- Averaging period for data should result in a turnover ratio of two or more.
  - Turnover ratio = (length of averaging period, yr)/(mass residence time, yr)
  - Mass residence time (yr) = (nutrient mass in reservoir, lb)/(external nutrient loading, lb/year)
- Includes analysis of data variability to estimate confidence in model predictions (through coefficient of variation).
- Additional information required for chl *a* based on empirical equation used.

Calculating Wasteload Allocations to Meet TP Criterion in Lakes and Reservoirs

BATHTUB Model General Considerations:

- Tributary loading obtained through FLUX model using fixed station data and USGS gaging station data.
  - FLUX maps flow/concentration relationship developed from the sample record onto entire flow record to calculate total mass discharged and associated error statistics.
- Tributary loading can also be obtained using a watershed model.
- Recommended to use at least three years of data to account for year to year variability.
- Will not predict episodic events such as algal blooms after fall turnover.
- Draft Pigeon River TMDL includes BATHTUB models for several lakes.
- EPA contractor provided IDEM with model input guidance (selection and calibration of empirical models, minimum data requirements, determination of internal load, model limitations).

Calculating Wasteload Allocations to Meet TP Criterion in Lakes and Reservoirs

BATHTUB Model General Considerations (continued):

- The U.S. Army Corps of Engineers is making improvements to the model and provides some support.
  - Conducted model training for Minnesota and the session is available online.
- BATHTUB requires:
  - Experience to understand its limitations and care to ensure that the empirical models used are appropriate for the lake being studied.
  - Knowledge of variability of inputs into the lake or reservoir and variability of in lake conditions to choose appropriate periods of data collection.
- The USDA has developed a procedure that can be helpful in developing insight into the sensitivity of different types of lakes and reservoirs to inputs of phosphorus.

Other States' Lake Nutrient Criteria Implementation Provisions

Ohio

- Have draft rule language that includes criteria for lakes and rivers, but only implementation procedures for rivers.
- In conducting TMDLs using benchmark nutrient criteria, Ohio has used the Generalized Watershed Loading Function Model (GWLF) to provide inputs to the BATHTUB model.

Other States' Lake Nutrient Criteria Implementation Provisions

Wisconsin

- Promulgated rules that include criteria for lakes and rivers.
- For direct discharges to lakes, the rules apply criteria to the undiluted discharge, but allow alternate limits based on a TMDL.
- Rules allow a more stringent downstream lake criterion to be applied in the mass balance calculation for a discharge to a lake tributary instead of the river criterion.
- The January 2012 implementation guidance states that a model such as BATHTUB could be used to determine limits for discharges to tributaries of lakes.

Other States' Lake Nutrient Criteria Implementation Provisions

Minnesota

- Promulgated rules that include criteria, but not implementation provisions.
- If a lake is not impaired, discharges to tributaries meet the standard treatment requirement for phosphorus (usually 1 mg/L).
- If the lake is impaired, they do an initial screen to determine if removal of a discharge would eliminate the impairment, and if so, prioritize for WQBEL development.
- If the discharge is not causing the impairment, they determine whether the discharge has reasonable potential to cause or contribute to the impairment.
- If a TMDL has not been done, pre-TMDL WQBELs may be established based on the WQBEL expected from a TMDL.
- They are actively working on using the BATHTUB model in watersheds.

Lakes and Reservoirs with Point Source Contributors of Phosphorus

By the Numbers:

	Natural Lakes	Reservoirs
Number with Point Source Contributors:	**26**	**24**
Number of Point Source Contributors:	30	137
Number with One Point Source Contributor:	23	4
Major Point Source Contributors:	3	20
Direct Point Source Dischargers:	6	10
Point Source Dischargers within 2 miles:	10	14
Point Source Contributors without TP Data:	4	65
Number with IU SPEA Student Data:	21	22
Number with IU SPEA Volunteer TP & Chl *a* Data:	7	1

Lakes and Reservoirs with Point Source Contributors of Phosphorus

By the Numbers:

	Natural Lakes	Reservoirs
Number with Point Source Contributors:	**26**	**24**
Number with Watershed Management Plan (WMP):	16	15
Number without WMP, but with Diagnostic Study:	4	5
Number included in Criterion Dataset:	21	23
- Data meet TP and Chl *a* criteria:	2	2
- Data meet only TP criterion:	0	1
- Data meet only Chl *a* criterion:	6	4

Implementation Examples Based on Point of Application of Criteria

Example 1: Criteria apply in the epilimnion at any point in the lake.

- Lake monitoring for assessment purposes could still be done at the deepest point.
- The regulations would continue to state that mixing zones for direct discharges to lakes are not allowed.
- Regulatory implementation procedures would be crafted to ensure that tributaries that receive point source discharges meet the lake criterion at the interface with the lake.
  - A stream design flow such as the harmonic mean flow would be established at the point the tributary enters the lake.
  - Background concentrations would be determined in the tributary prior to entrance into the lake.

Implementation Examples Based on Point of Application of Criteria

Example 1 (continued):

- A mass balance calculation would be done to calculate the effluent total phosphorus concentration that will not raise the stream design flow above the criterion after 100% mixing.
- This effluent concentration would become the wasteload allocation which would be translated into monthly average and weekly average (for sanitary discharges) WQBELs that would apply year round.

- **Question:** Would the assimilation of phosphorus in the tributary be considered for discharges beginning at a specified distance from the lake?

Implied Policy Decision: Dilution in the lake or reservoir and sedimentation will not be allowed as a means to meet TP criterion.

Implementation Examples Based on Point of Application of Criteria

Example 1 Implementation Thoughts:

- Having procedures in regulation would add clarity and defensibility to the permit limit development process for total phosphorus.
- Requires only tributary data and not lake data to implement.
- An IDEM analysis of probabilistic data collected May through October for the period 1996 through 2006 shows mean total phosphorus concentrations exceed the lake and reservoir criteria in all watersheds statewide.

Implementation Examples Based on Point of Application of Criteria

Example 1 Implementation Thoughts (continued):

- A lack of assimilative capacity in tributaries could force permit limits below concentrations that may be considered achievable through current affordable treatment technology.
- May require consideration of a streamlined variance approach.
- If an assessment shows that the lake is impaired, a TMDL could allow for higher permit limits.
- An analysis of assimilation in the tributary could raise permit limits, but would require additional resources to implement.

Implementation Examples Based on Point of Application of Criteria

Example 2: In the epilimnion at the deepest point of the lake

- Lake monitoring for assessment purposes done at the deepest point.
- Regulations would continue to state that mixing zones for direct discharges to lakes are not allowed.
- Regulatory implementation procedures would only contain essential elements to allow for flexibility in developing wasteload allocations.
- Once a wasteload allocation is established, it would be translated into monthly average and weekly average (for sanitary discharges) permit limits that would apply year round.
- Initial screen of dischargers to tributaries of lakes could be made to determine whether additional treatment alone may allow a lake or reservoir to meet the total phosphorus criterion if it is impaired.

Implementation Examples Based on Point of Application of Criteria

Example 2 (continued):

- A priority could be placed on obtaining information to develop a defensible wasteload allocation for discharges that by themselves may be causing an exceedance of the total phosphorus criterion.
- A priority list of lakes and reservoirs could be developed to assess for compliance with the criteria and to collect information needed to conduct TMDLs. Lakes without point source discharges to tributaries may be listed as a higher priority than those with contributing point source discharges.
- If an assessment shows that a lake is meeting the total phosphorus criterion, then wasteload allocations for point source discharges would not be calculated and only the treatment technology requirements under 327 IAC 5-10-2 for discharges within 40 miles of a lake, or the lake discharger requirements under 5-10-4, if applicable, would apply.

Implementation Examples
Based on Point of Application of Criteria

Example 2 (continued):

- If assessment shows that a lake is not meeting the TP criterion, a determination would be made whether the discharge has a reasonable potential to cause or contribute to the exceedance of the criterion.
- If the discharge shows reasonable potential, pre-TMDL WQBELs would be established.
- If the discharge does not show reasonable potential, only the requirements under 5-10-2 or 5-10-4 would apply.
- **Question:** Would the assimilation of phosphorus in the tributary be considered for discharges beginning at a specified distance from the lake or reservoir?

Implementation Examples Based on Point of Application of Criteria

Example 2 Implementation Thoughts:

- Regulations would be more flexible, but not as clear and defensible as Example 1.
- Would require additional data collection and modeling resources.
- A process for screening discharges to determine if they cause or have the reasonable potential to cause or contribute would have to be developed.
- A process for developing pre-TMDL WQBELs would have to be developed.
- TMDLs are typically done on a 10-digit watershed so it may take longer to get to some impaired lakes with point source contributors in watersheds with low priority.
- CWA 319 watershed plans and LARE diagnostic studies could expedite the modeling process for some lakes.

Resources

IDEM Algae Website: http://www.in.gov/idem/algae/

Indiana Clean Lakes Program: http://www.indiana.edu/~clp/index.php

Minnesota PCA BATHTUB Model Information and Training:
http://www.pca.state.mn.us/index.php/water/water-types-and-programs/surface-water/lakes/lake-water-quality/bathtub-model.html

***A Procedure to Estimate the Response of Aquatic Systems to Changes in Phosphorus and Nitrogen Inputs*, USDA, 1999:**
http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb1044774.pdf

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